Highly sensitive but easy to handle: test strips for the rapid detection of cocaine

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Saving the life of a poisoning victim is often a matter of minutes. It is best when the emergency doctor can perform a reliable diagnosis on the spot to determine which poison or what type of drug overdose a patient is suffering from. Complicated laboratory analyses and a complex apparatus are out of place in the emergency room.

A team at the University of Illinois in Urbana has now laid the foundation for a new generation of rapid diagnostic tests that are as easy to handle as a pregnancy test: just dunk them in the sample and see if a colored band appears. These test strips are as reliable as laboratory methods. As a prototype, the researchers led by Yi Lu developed a test strip for the detection of cocaine in biological samples such as saliva, urine, and blood serum.

“Our method is based on tiny gold spheres and aptamers,” reports Lu. Aptamers are single-stranded nucleic acid molecules that bind to certain target molecules with the same strength and specificity as antibodies. From a large number of DNA strands with random sequences (a library), it is basically possible to find a suitable aptamer for almost every target molecule.

Says Lu: “The broad practical application of aptamers has thus far not realized its promise in practical diagnostics because the corresponding tests could not be made sufficiently user-friendly for the average user, who has not had laboratory training.”

The new test strips for cocaine are different. When the end of the strip is dipped into a sample, the liquid travels along the strip to reach a zone with small gold-aptamer clumps. The trick lies in the special structure of these clumps: they are aggregates of nanoscopic gold spheres coupled to short DNA strands, some containing the biomolecule biotin. The DNA sequences are complementary to two regions of the cocaine-specific DNA aptamer. The aptamers bind to these strands, linking the gold spheres into larger aggregates.

When the cocaine-containing liquid reaches these aggregates, the cocaine molecule instantly binds to the aptamers and removes them from the network; the aggregates fall apart into individual gold spheres. These free spheres are red. When the liquid travels further along the strip, it reaches a membrane. While the larger gold aggregates are stopped by the membrane, the red gold spheres are small enough to pass through it. They end up stuck to a narrow strip of streptavidin, a biomolecule that grabs onto the biotin on the gold surface like a hook onto an eye. The gold spheres get concentrated on the narrow strip and become visible as a distinct red stripe on the test strip.

“Our method is universal,” stresses Lu. “Based on this principle, we should be able to develop rapid tests for the emergency diagnosis of a large number of drugs and poisons, as well as physiological molecules. The same method is also applicable to environmental monitoring.”

Citation: Yi Lu et al., A Simple and Sensitive "Dip-Stick" Test in Serum Based on Lateral Flow Separation of Aptamer-Linked Nanostructures, *Angewandte Chemie International Edition* 2006, 45, No. 47, 7956–7959, doi: 10.1002/anie.200603106

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